

CLAIMS

We claim:

- 1 1. A method for determining a submarine geographic position, the method comprising the steps  
2 of:
  - 3 a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS  
4 geographic position estimate, wherein said DRNS geographic position estimate is  
5 determined by a DRNS;
  - 6 b) recording a buoy breach time and searching for radio navigation signals, wherein said  
7 buoy breach time is subsequent to said launch time;
  - 8 c) recording a radio navigation position acquisition time and an initial radio navigation  
9 position, wherein said subsequent time is subsequent to said buoy breach time;
  - 10 d) recording a subsequent radio navigation position and a subsequent time, wherein said  
11 subsequent time is subsequent to said radio navigation position acquisition time;
  - 12 e) determining a DRNS correction factor using a DRNS position error, a buoy drift, radio  
13 navigation position data and DRNS position data;
  - 14 f) estimating said submarine geographic position using said DRNS correction factor and  
15 said DRNS geographic position estimate.
- 1 2. The method of Claim 1, wherein said radio navigation-enabled buoy comprises a GPS-  
2 enabled buoy.
- 1 3. The method of Claim 1, wherein said DRNS position error is determined by extrapolating a  
2 radio navigation/drift estimated geographic position of said radio navigation-enabled buoy at  
3 said buoy breach time using a radio navigation/drift position and said buoy drift and  
4 comparing said radio navigation/drift estimated geographic position of said radio navigation-  
5 enabled buoy at said buoy launch time to a launch time DRNS geographic position estimate  
6 of said submarine at said buoy launch time.
- 1 4. The method of Claim 1, wherein said DRNS is an INS.

1 5. The method of Claim 1, wherein said determining a DRNS correction factor using DRNS  
2 position error, buoy drift, radio navigation position data and DRNS position data comprises  
3 the following sub-steps:

4 i) extrapolating a radio navigation/drift estimated geographic position of said radio  
5 navigation-enabled buoy at said buoy breach time using radio navigation position  
6 data and said buoy drift;

7 ii) comparing said radio navigation/drift estimated geographic position of said radio  
8 navigation-enabled buoy at said buoy breach time to a DRNS estimated geographic  
9 position of said submarine at said buoy launch time;

10 iii) determining said DRNS correction factor from said DRNS position error.

1 6. The method of Claim 5, wherein said extrapolating a radio navigation/drift estimated  
2 geographic position of said radio navigation-enabled buoy at said buoy breach time  
3 comprises the following sub-steps:

4 (1) determining said buoy drift by comparing said initial radio navigation position  
5 data to said subsequent radio navigation position and said radio navigation  
6 position acquisition time to said subsequent time;

7 (2) extrapolating a radio navigation/drift estimated geographic position of said radio  
8 navigation-enabled buoy at said buoy breach time using radio navigation position  
9 data and said buoy drift.

1 7. The method of Claim 5, wherein said extrapolating a radio navigation/drift estimated  
2 geographic position of said radio navigation-enabled buoy at said buoy breach time by the  
3 following sub-steps:

4 (1) determining a latitude displacement and a longitude displacement by multiplying  
5 a latitude drift velocity by an elapsed time and a longitude drift velocity by said  
6 elapsed time, wherein said elapsed time equals a first event time subtracted from a  
7 second event time;

8 (2) subtracting said latitude displacement and said longitude displacement to a  
9 navigation position associated with said second event time.

1 8. The method of Claim 7, wherein said first event time is said buoy breach time, and wherein  
2 said second event time is said radio navigation position acquisition time, and wherein said  
3 second event time is subsequent to said first event time.

1 9. The method of Claim 1, wherein said buoy drift is represented by latitude/longitude  
2 displacement over time.

1 10. The method of Claim 1, wherein said method is performed by a processing means.

1 11. The method of Claim 10, wherein said processing means includes a submarine navigation  
2 computer.

1 12. The method of Claim 10, wherein said processing means includes a buoy computer and a  
2 navigation computer.

1 13. A submarine launched radio navigation buoy system, comprising:

2 a) a submarine launched radio navigation buoy, capable of:

3 i) launching from a submerged submarine;

4 ii) obtaining a plurality of radio navigation positions from radio navigation RF signals  
5 and a plurality of corresponding event times;

6 iii) transmitting said plurality of corresponding event times and said plurality of radio  
7 navigation positions;

8 b) a processing means, operatively coupled to said submarine launched radio navigation  
9 buoy, capable of:

10 i) receiving said plurality of corresponding event times and said plurality of radio  
11 navigation positions;

12 ii) determining a DRNS correction factor using a DRNS position error, a buoy drift,  
13 radio navigation position data and DRNS position data;

14 iii) estimating a submarine geographic position using said DRNS correction factor and a  
15 DRNS geographic position.

1 14. The submarine launched radio navigation buoy system of Claim 13, wherein said submarine  
2 launched radio navigation buoy is a GPS-enabled buoy.

1 15. The submarine launched radio navigation buoy system of Claim 13, wherein said processing  
2 means determines said DRNS position error is determined by extrapolating a radio  
3 navigation/drift estimated geographic position of said radio navigation-enabled buoy at said  
4 buoy breach time using a radio navigation/drift position and said buoy drift and comparing  
5 said radio navigation/drift estimated geographic position of said radio navigation-enabled  
6 buoy at said buoy breach time to a DRNS estimated geographic position of said submarine at  
7 said buoy launch time.

1 16. The submarine launched radio navigation buoy system of Claim 13, wherein said processing  
2 means determines a DRNS correction factor using DRNS position error, buoy drift, radio  
3 navigation position data and DRNS position data comprises the following sub-steps:

4 i) extrapolating a radio navigation/drift estimated geographic position of said radio  
5 navigation-enabled buoy at said buoy breach time using radio navigation position  
6 data and said buoy drift;

7 ii) comparing said radio navigation/drift estimated geographic position of said radio  
8 navigation-enabled buoy at said buoy breach time to a DRNS estimated geographic  
9 position of said submarine at said buoy launch time;

10 iii) determining said DRNS correction factor from said DRNS position error.

1 17. The submarine launched radio navigation buoy system of Claim 16, wherein said processing  
2 means extrapolates a radio navigation/drift estimated geographic position of said radio  
3 navigation-enabled buoy at said buoy breach time comprises the following sub-steps:

4 (1) determining said buoy drift by comparing said initial radio navigation position  
5 data to said subsequent radio navigation position and said radio navigation  
6 position acquisition time to said subsequent time;

7 (2) extrapolating a radio navigation/drift estimated geographic position of said radio  
8 navigation-enabled buoy at said buoy breach time using radio navigation position  
9 data and said buoy drift.

1 18. The submarine launched radio navigation buoy system of Claim 16, wherein said processing  
2 means extrapolates a radio navigation/drift estimated geographic position of said radio  
3 navigation-enabled buoy at said buoy breach time by the following sub-steps:

4 (1) determining a latitude displacement and a longitude displacement by multiplying  
5 a latitude drift velocity by an elapsed time and a longitude drift velocity by said  
6 elapsed time, wherein said elapsed time equals a first event time subtracted from a  
7 second event time;

8 (2) subtracting said latitude displacement and said longitude displacement to a  
9 navigation position associated with said second event time.

1 19. A submarine launched radio navigation buoy system, comprising:

2 a) means for launching a radio navigation-enabled buoy;

3 b) means for recording a launch time, a DRNS geographic position estimate, a buoy breach  
4 time, a radio navigation position acquisition time and a subsequent time, wherein said  
5 subsequent time is subsequent to said radio navigation position acquisition time, which is  
6 subsequent to said buoy breach time, which is subsequent to said launch time;

7 c) means for searching for and receiving radio navigation signals;

8 d) means for recording an initial radio navigation position and a subsequent radio navigation  
9 position;

10 e) means for determining a DRNS correction factor using a DRNS position error, a buoy  
11 drift, radio navigation position data and DRNS position data;

12 f) means for estimating said submarine geographic position using said DRNS correction  
13 factor and a DRNS geographic position.

1 20. A method for determining a submarine geographic position, the method comprising the steps  
2 of:

3 a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS  
4 geographic position estimate, wherein said DRNS geographic position estimate is  
5 determined by a DRNS;

- b) recording a buoy breach time and searching for radio navigation signals, wherein said buoy breach time is subsequent to said launch time;
- c) recording a radio navigation position acquisition time and an initial radio navigation position, wherein said subsequent time is subsequent to said buoy breach time;
- d) determining a DRNS correction factor using a DRNS position error, a buoy drift, radio navigation position data and DRNS position data, wherein said buoy drift is received from a DRNS associated with said radio navigation-enabled buoy;
- e) estimating said submarine geographic position using said DRNS correction factor and said DRNS geographic position estimate.

21. A method for determining a submarine geographic position, the method comprising the steps of:

- a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS geographic position estimate, wherein said DRNS geographic position estimate is determined by a DRNS;
- b) recording a buoy breach time and searching for radio navigation signals, wherein said buoy breach time is subsequent to said launch time;
- c) recording a radio navigation position acquisition time and an initial radio navigation position, wherein said subsequent time is subsequent to said buoy breach time;
- d) determining a DRNS correction factor using a DRNS position error, a buoy drift, radio navigation position data and DRNS position data, wherein said buoy drift is received from a sonar system capable of tracking said radio navigation-enabled buoy;
- e) estimating said submarine geographic position using said DRNS correction factor and said DRNS geographic position estimate.